



Designation: C596 – 23

Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement¹

This standard is issued under the fixed designation C596; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method determines the change in length on drying of mortar bars containing hydraulic cement and graded standard sand.

1.2 The values stated in SI units are to be regarded as standard. When combined standards are referenced, the selection of measurement system is at the user's discretion subject to the requirements of the referenced standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.²

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*³

C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

C219 Terminology Relating to Hydraulic and Other Inorganic Cements

C305 Practice for Mechanical Mixing of Hydraulic Cement

Pastes and Mortars of Plastic Consistency

C490/C490M Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete

C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C778 Specification for Standard Sand

C1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in Physical Testing of Hydraulic Cements

C1437 Test Method for Flow of Hydraulic Cement Mortar
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

3. Terminology

3.1 The term “drying shrinkage” is defined as the decrease in length of the test specimen, where the decrease is caused by any factor other than externally applied forces under stated conditions of temperature, relative humidity and evaporation rate in the environment; the term includes the net effect of a variety of phenomena tending to bring about both increases and decreases in length during the period in which the test specimens under consideration are stored in the environment and in which a number of processes, including hydration of the cement, are taking place at a variety of rates.

3.2 Other terms used in this test method are defined in Terminology C219.

4. Significance and Use

4.1 This test method establishes a selected set of conditions of temperature, relative humidity and rate of evaporation of the environment to which a mortar specimen of stated composition shall be subjected for a specified period of time during which its change in length is determined and designated “drying shrinkage.”

4.2 The drying shrinkage of mortar as determined by this test method has a linear relation to the drying shrinkage of concrete made with the same cement and exposed to the same

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² Section on Safety, *Manual of Cement Testing, Annual Book of Standards*, Vol. 04.01.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

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drying conditions.⁴ Hence this test method may be used when it is desired to develop data on the effect of a hydraulic cement on the drying shrinkage of concrete made with that cement.

5. Apparatus

5.1 *Weighing Devices and Weights*—Weighing devices and weights used in determining the mass of materials for mortar mixtures shall conform to the requirements of Specification C1005.

5.2 *Glass Graduates*—Glass graduates of suitable capacities shall conform to the requirements of Specification C1005.

5.3 *Molds*—Molds shall conform to the requirements of Practice C490/C490M for mortars.

5.4 *Trowel*—The trowel shall have a straight-edged steel blade 100 mm to 150 mm in length.

5.5 *Tamper*—The tamper shall conform to the requirements of Test Method C157/C157M.

5.6 *Demolding Apparatus*—The demolding apparatus shall conform to the requirements of Test Method C157/C157M.

5.7 *Length Comparator*—The length comparator shall conform to the requirements of Practice C490/C490M.

6. Materials

6.1 Graded standard sand shall conform to Specification C778.

7. Sampling and Test Specimens

7.1 A sample consists of four test specimens from a single batch of mortar.

7.2 Prepare at least one sample batch consisting of four test specimens according to Section 9. (Note 1).

NOTE 1—It is preferable that three sample batches be prepared, for twelve specimens total, with each of the three batches being made on a different day.

8. Conditioning

8.1 *Temperature, Humidity, and Water Conditioning:*

8.1.1 *Laboratory*—The temperature of the laboratory, dry materials, and mixing water, and the relative humidity of the air in the laboratory shall conform to the requirements of Specification C511.

8.1.2 *Moist Cabinet and/or Moist Room*—The temperature and humidity of the air in the moist cabinet or moist room shall conform to the requirements of Specification C511.

⁴ Data pertaining to the relation of the drying shrinkage of mortar test specimens and of the drying shrinkage of concrete test specimens as affected by the cement under specified laboratory test conditions, may be found in RR.C01-0120, available from ASTM Headquarters; in a report of the California Division of Highways, "Significance of the Test for Contraction of Mortar in Air with Respect to Performance of Cements in Concrete," Oct. 18, 1961; and in the paper by Marduller, F. J., Schneider, A. M., and Stockert, A. L., "An Analysis of Drying Shrinkage Data for Portland Cement Mortar and Concrete," *Journal of Materials*, JMLSA, Am. Soc. Testing Mats., Vol. 2, No. 4, 1967, pp. 829-842. A relevant paper by H. T. Ami entitled "The Significance of the Correlation Coefficient for Analyzing Engineering Data" was published in *Materials Research and Standards*, MTRSA, Am. Soc. Testing Mats., Vol. 11, No. 5, 1971, pp. 16-19.

8.1.3 *Water Storage Tank*—The water temperature and lime-saturation state of the water storage tank shall conform to the requirements of Specification C511.

8.1.4 *Drying Room and Controls*—The drying room and controls shall conform to the requirements of Test Method C157/C157M.

8.2 *Curing and Storage*—Cure, store, and take comparator readings of the test specimens as required by Test Method C157/C157M, except as indicated in 9.3 of the Procedure.

9. Procedure

9.1 Prepare the specimen molds as required by Practice C490/C490M.

9.2 Prepare the test specimens.

9.2.1 *Mortar Proportions*—A batch of mortar shall consist of 750 g of cement, 1500 g of graded standard sand, and an amount of mixing water sufficient to produce a flow of 105 % to 115 %. The flow shall be determined in conformance with the procedure as described in Test Method C1437.

9.2.2 *Mixing Mortar*—Mix the mortar in a mechanical mixer as required by Practice C305.

9.2.3 *Molding of Specimens*—Mold the specimens as required by Test Method C157/C157M.

9.3 Cure, store and take comparator reading of the test specimens.

9.3.1 Moist cure the specimens in the molds for 24 h \pm 30 min. If the strength of the specimens is insufficient to allow proper removal from the mold at 24 h, moist cure in the mold for 48 h \pm 30 min.

9.3.2 Remove the specimens from the molds and cure in lime-saturated water for 48 h. If the specimens have been moist cured in the mold for 48 h, cure in lime-saturated water for 24 h.

9.3.3 At the age of 72 h \pm 30 min, remove the specimens from water, wipe with a damp cloth, and immediately obtain a length comparator reading for each specimen.

9.3.4 Place the specimens in air storage for 25 days.

9.3.5 Obtain a length comparator reading for each specimen after 4, 11, 18, and 25 days of air storage, which is equal to 1, 2, 3, and 4 weeks of total curing time, respectively.

10. Preparation of Test Specimens

10.1 *Mortar Proportions*—A batch of mortar shall consist of 750 g of cement, 1500 g of graded standard sand, and an amount of mixing water sufficient to produce a flow of 110 % \pm 5 %. The flow shall be determined in conformance with the procedure as described in Test Method C1437.

10.2 *Mixing Mortar*—Mix the mortar in a mechanical mixer as required by Practice C305.

10.3 *Molding of Specimens*—Mold the specimens as required by Test Method C157/C157M.

11. Curing, Storage, and Taking Comparator Readings of Test Specimens

11.1 Cure, store, and take comparator readings of the test specimens as required by Test Method C157/C157M, except as follows:

11.1.1 Moist cure the specimens in the molds for 24 h ± 30 min. If the strength of the specimens is insufficient to allow proper removal from the mold at 24 h, moist cure in the mold for 48 h ± 30 min.

11.1.2 Remove the specimens from the molds and cure in lime-saturated water for 48 h. If the specimens have been moist cured in the mold for 48 h, cure in lime-saturated water for 24 h.

11.1.3 At the age of 72 h ± 30 min remove the specimens from water, wipe with damp cloth and immediately obtain a length comparator reading for each specimen. Then place the specimens in air storage for 25 days. Obtain a length comparator reading for each specimen after 4, 11, 18, and 25 days of air storage.

12. Calculation of Drying Shrinkage

12.1 The difference between the initial comparator reading and the final readings, as a percent of effective gauge length, represents the drying shrinkage.

12.2 Calculate the drying shrinkage of each specimen by subtracting the comparator reading taken at each age of air drying from the initial comparator reading, taken after removal from water storage, and express as the percent of the effective gauge length as follows:

$$L = \frac{(L_i - L_x)}{G} \times 100 \quad (1)$$

where:

L = drying shrinkage at x age, %.

L_i = initial comparator reading of specimen minus comparator reading of reference bar at that same time.

L_x = comparator reading of specimen at x age minus comparator reading of reference bar at x age, and

G = nominal gauge length, 250 mm when using molds in SI units, 10 in. when using molds in inch-pound units.

12.3 Calculate drying shrinkage values for each specimen to the nearest 0.001 % and report averages to the nearest 0.01 %.

13. Report

13.1 Report the average drying shrinkage of four specimens from the same batch of mortar as the drying shrinkage of the mortar, to the nearest 0.01 %.

13.2 If any one test specimen is manifestly faulty, discard it.

13.3 If more than one test specimen is discarded, do not report the results and repeat the test on a new batch of mortar.

13.4 If more than one batch of mortar has been tested, report the average result of the individual batches.

13.5 When the experimenter is clearly aware that a gross deviation from prescribed experimental procedure has taken place, discard the resultant observation, whether or not it agrees with the rest of the data and without recourse to statistical tests for outliers.

Note 2—An approximation of ultimate drying shrinkage of mortar may be determined by plotting the shrinkage values as a function of the reciprocal of the time. The time includes the moist curing period. An example of the method is given in Fig. 1 where a logarithmic scale is used for the drying shrinkage values and a reciprocal scale for the total time in weeks.

14. Precision and Bias

14.1 Precision:

14.1.1 *Single-laboratory Precision*—The single-laboratory multi-batch standard deviation among test results determined from the average of four test specimens has been determined to be 0.0029 %. Therefore, the difference between two test results

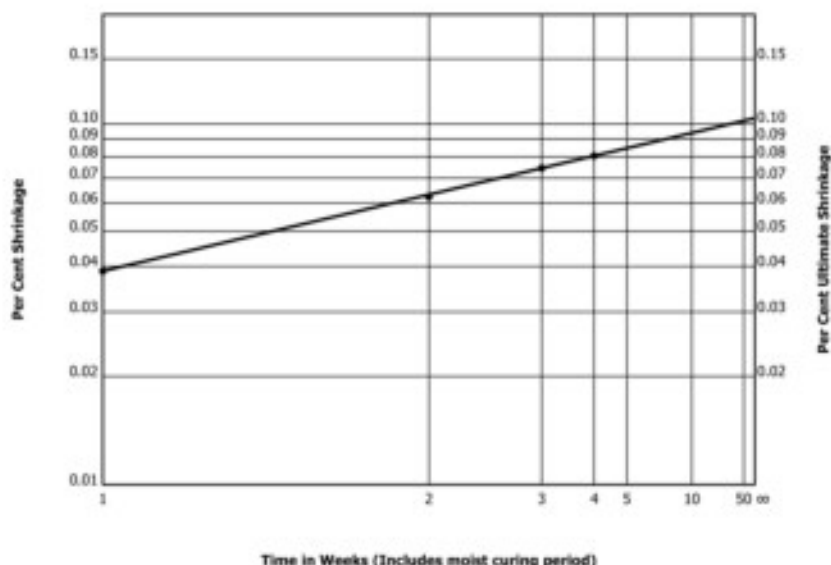


FIG. 1 Ultimate Drying Shrinkage of Mortar

made two different batches of mortar should agree to within 0.0081 % in 95 % of such two-batch comparisons.⁵

14.1.2 *Multi-Laboratory Precision*—The coefficient of variation for multi-laboratory test results determined using four test specimens per batch was determined to be 14.7 %.

⁵These numbers represent the difference limits (d_{2s}) as described in Practice C670.

Therefore, the difference in test results between two laboratories is expected to agree to within 41 % of their mean in 95 % of such two-laboratory comparisons.⁵

14.2 *Bias*—No justifiable statement can be made on the bias of this test method since no reference samples are available.

15. Keywords

15.1 drying shrinkage; hydraulic cement; method; mortar

SUMMARY OF CHANGES

Committee C01 has identified the location of selected changes to this standard since the last issue (C596 – 18) that may impact the use of this standard. (Approved Dec. 1, 2023.)

- (1) Revised Section 12.
- (2) Split Section 12 into a Calculation section and a Report section.
- (3) Revisions made to conform to Form and Style affecting Sections 6 Temperature and Humidity, 7 Sampling and Preparation, 8 Number of Test Specimens, 9 Preparation of Molds, 10 Preparation of Test Specimens, and 11 Curing, Storage, and Taking Comparator Readings of Test Specimens.

- (4) Newly revised sections containing language from the old Sections include Sections 6 Materials, 7 Sampling and Test Specimens, 8 Conditioning, and 9 Procedure.
- (5) Subsequent sections to be renumbered editorially.

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